Abstract No. Crof0362

Application of Synchrotron EDXRD Strain Profiling in Shot Peened Materials

M. Croft[1,2], I. Zakharchenko[1], Y. Gulak[1], Z. Zhong[2], M. Dasilva[1] and T.Tsakalakos[1] ([1]Rutgers Univ., [2]NSLS, BNL)

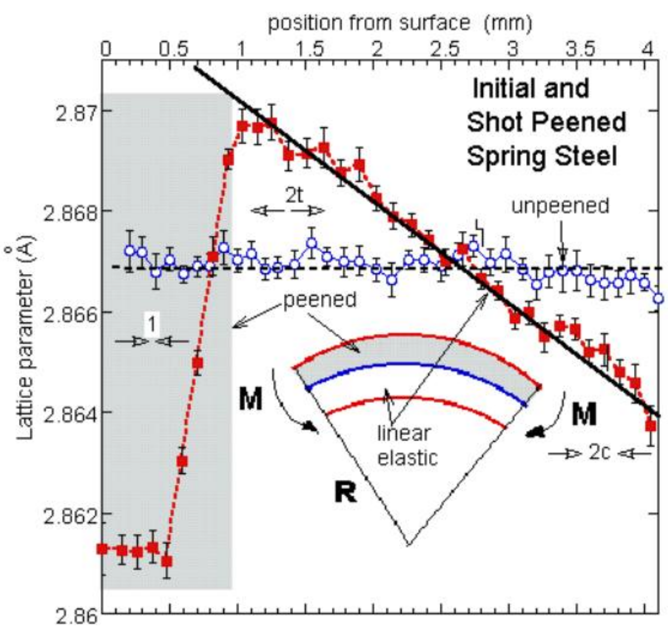
Beamline(s): X17B1

Failure of cyclic load-bearing components is, more often than not, near surface initiated. In particular, processing or duty cycle induced surface tensile stresses greatly accelerate failure due to the surface-initiated crack growth. The near surface compression, induced by shot peening, has made it a classic industrial technique to extend the loading limits and fatigue lives of a multitude of components varying from dental picks to airplane wings [1]. The high impact velocity of the peening shot causes a biaxial surface expansion and a near-surface plastic region, which is rendered in a state of compression. A photomicrograph of the impact pitting of a heavily peened surface is shown in Figure 1. Characterization of both the detailed magnitude and depth of the shot peening surface compression are crucial to fundamental understanding this important processing technique. Energy dispersive x-ray diffraction (EDXRD) [2] offers a direct nondestructive method of strain depth profiling ideally suited to studies of shot peened test materials.

In Figure 2 we show the strain profile of an unpeened 3.85 mm thick spring steel placket which provides an essentially strain free standard. In the shot peening industry placket curvature is used to quantify the peening intensity through the induced stress/bending-moment. A schematic of the peened placket, with exaggerated curvature, and bending moment M, is inset in Figure 2.

The lattice parameter (a) profile (see Figure 2), of a spring-steel placket, peened by 1.4 mm hard steel shot to a curvature radius of R_A=1.65 m, manifests dramatic internal strains. The peening induced compressive strain extends to a depth of about 0.7 mm (region 1). The underlying steel (region 2) responds to the peened layer elastically, with the bending moment creating a linear elastic strain vs. position in region 2 given by $(a-a_0)/a_0 = y/R$ where y is the depth in the sample measured from its center and a_0 is the average lattice parameter across the sample.. Least squares fitting the linear portion of the region 2 data yields a microscopically determined curvature of R= 1.53 m in quite good agreement with the macroscopic curvature.

In region 2 an equilibrium-required balancing interior tensile strain extends over a wide depth range (region 2t). The linear elastic response over shoots the null-strain to yield a compressive elastic strain near the unpeened surface also (region 2c). Such a compressive elastic stress is to be expected at this concave surface. Thus our strain profiling method provides a direct and clear quantitative method of characterizing the detailed internal strain distribution in such important peening modified materials.



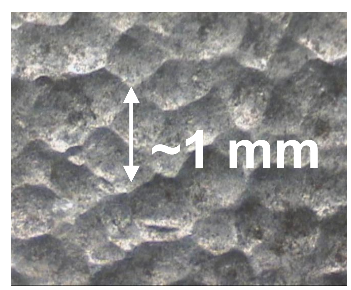


Figure 1. A photomicrograph of the peened surface of the 3.85 mm thick specimen.

Figure 2. Measured lattice parameter profile for a 3.85mm thick spring steel placket peened with 1.4mm hard steel shot.

[1] . We gratefully acknowledge the valuable assistance/collaboration of James Groark and Eduard Denny of the Metal Improvement Co. Inc. for samples, discussions and curvature measurements.

[2] See M. Croft, I. Zakharchenko, Y. Gulak, Z. Zhong J. Hastings, J. Hu, R. Holtz, M. DaSilva , and T.Tsakalakos, Jour. Appl. Phys. **92**, 578(2002) and references therein

Supported by ONR grants N000149910424 and DURINT –MIT N00014-01-1-0808.